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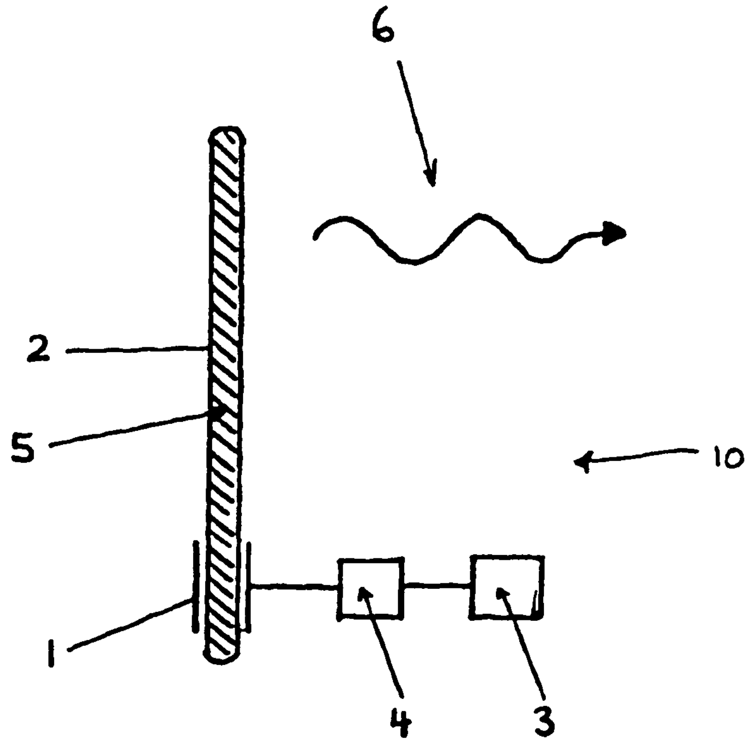
(54) Title: PLASMA ANTENNA

(57) Abstract

A system (10) for information transmission having a plasma antenna (5), including an electrodeless plasma tube (2), and a power source effective to generate an electromagnetic field to cause ionisation of material within the tube so as to form the antenna for one or both of either sending or receiving signals, wherein the electromagnetic field is applied to a portion only of the tube. The system preferably includes a terminal (1) arranged about a base of the tube for establishing the electromagnetic field upon application of power from the power source, to induce surface wave ionisation within the tube.



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PLASMA ANTENNA

Technical Field

The present invention relates to a new type of plasma antenna for use in an information transmission system and, in particular, to a surface wave driven plasma antenna formed within a dielectric tube enabling furtive communications.

Background of the Invention

Presently, antennas based on a plasma discharge are known. US Patent 5594456 discloses a device whereby a pulsed plasma antenna is utilised for the transmission and reception of signals in Ground Penetrating Radar and high speed data communication applications. However, this device requires metallic electrodes with associated wires and a radio-frequency decoupling device to drive the plasma antenna which limit its applicability as a communications device and more specifically as a furtive communications device.

A surface wave driven plasma is also known, as set out in the publication Burykin Yu I., Levitskiy S. M. and Martyneko V. G. (1975) Radio Eng. Electron. Phys. **20**, 86. However this publication does not concern itself with developing the plasma as a communications device. It is not obvious in the slightest that the combination of the abovementioned prior art would produce the present invention.

Conventional conducting element antennas are also known and used widely. However, these antennae are not furtive due to their metallic components. Additionally, plasma antennas may be made flexible in the sense that the radiation pattern may be altered by changing the plasma density, or conversely maintaining the radiation pattern when the frequency is altered. These possibilities are not possible with simple metallic elements in conventional antennas.

This identifies a need for an improved type plasma antenna using a furtive means of operation and overcoming the problems inherent in the prior art.

Summary of the Invention

In accordance with the invention, there is provided a system for information transmission having a plasma antenna, including:

an electrodeless plasma tube; and

a power source effective to generate an electromagnetic field to cause ionisation of material within the tube so as to form the antenna for one or both of either sending or receiving signals, wherein the electromagnetic field is applied to a portion only of the tube.

Preferably, system as claimed in claim 1, wherein the system includes a terminal arranged about the tube at said portion for establishing the electromagnetic field upon application of power from the power source to induce surface wave ionisation within the tube.

The use of surface wave ionisation provides a significant advantage over the antenna disclosed in US 5594456 in that the plasma can be formed utilising only a single terminal and the metallic electrodes of the prior art may be dispensed with. This has particular advantage in stealth applications where metal componentry needs to be minimised to reduce a radar cross-section. Further, a single terminal may be used to both derive the plasma and generate a transmission signal which reduces component parts. Another specific advantage is that the antenna is tunable in the sense that the extent of surface wave ionisation can be controlled, allowing for dynamic control of the length and thereby operational frequency of the antenna. None of these advantages are contemplated or suggested in the prior art.

Preferably, the system comprises a furtive wireless communications device, said apparatus acting as either, or both, the transmitter and the receiver. By "furtive" is meant that the

antenna is only in existence and detectable when in operation. As soon as ionising power is terminated, the antenna ceases to exist.

Preferably, the system employs a means to use multiple frequencies simultaneously for the functions of plasma formation and maintenance, and signal transmission and reception.

Preferably, the plasma density and/or plasma dielectric properties is/are controllable by external means including, but not limited to, radio-frequency power supplied to said plasma excitation means, the frequency of said radio-frequency power, phase changes of the radio-frequency power, an applied magnetic field, the gas pressure or a gases partial pressure.

In another aspect, there is provided a method of communication, including providing an electrodeless plasma tube an establishing a plasma in the tube by surface wave ionisation to form a plasma antenna for one or both of either receipt or transmission of signals.

Preferably, the method includes controlling the plasma density and/or plasma dielectric properties by external means including, but not limited to, the radio-frequency power supplied to said plasma excitation means, the frequency of said radio-frequency power, phase changes of the radio-frequency power, an applied magnetic field, the gas pressure or a gases partial pressure.

Preferably, the method includes providing an array of plasma tubes, individual tubes being arranged and excited as to selectively permit control of the overall radiation pattern arising from the array of antennae, the mutual coupling between individual antennae, frequency stepping of individual antennae, power loading of individual antennae, and the tuning of the array of antennae.

<u>Brief Description of the Drawings</u>

The present invention will become better understood from the following detailed description of a preferred but non-limiting embodiment thereof, described in connection with the accompanying drawings, wherein:

Figure 1 illustrates a system of the invention; and
Figure 2 illustrates an antenna array utilising the system of Figure 1.

Detailed Description of the Preferred Embodiment

A system 10 for information transmission or receipt is shown in Figure 1. The system 10 has a terminal in the form of a cylindrical copper sleeve 1 wrapped around a base of an electrode-less dielectric tube 2.

A radio-frequency (RF) power generator 3 supplies RF power to the copper sleeve via impedance matching circuitry 4. The copper sleeve establishes an electromagnetic field in the tube which causes surface wave ionisation of material within the tube such that a plasma antenna 5 is created and maintained within the dielectric tube. The length of the copper sleeve may be adjusted to minimise spurious harmonic generation during coupling.

The antenna 5 may be utilised for either sending or receiving communications signals. To send a signal 6 the surface wave may be made to propagate in the plasma so as to induce a net radio-frequency current to flow along the antenna, this current generates electromagnetic waves that may be transmitted from the antenna in the form of the signal 6. For multiple frequency operation, multiple sleeve couplers can be employed.

Power from the generator 3 may also be controlled to limit the extent of the surface wave along the tube 2 in order to vary the length of the antenna and thereby its operating frequency, as required. Additionally, or alternatively, the physical characteristics of the plasma may be modified to alter operational parameters, such as by controlling the plasma density and/or plasma dielectric properties by external means including, but not limited to,

the radio-frequency power supplied to said plasma excitation means, the frequency of said radio-frequency power, phase changes of the radio-frequency power, an applied magnetic field, the gas pressure or the partial pressures of a mix of gases. Changes in the radiation pattern can be produced by altering the plasma density, or conversely by maintaining a constant radiation pattern by varying the frequency.

Aside from the adaptability of the antenna with respect to signal output, the system has a particular advantage insofar as radar detectability. As there is only a single terminal (or radio-frequency feed point) at one end of the plasma tube, or in any event about only a portion of the tube 2, and no conducting connection to the other end of the tube, the antenna in its present embodiment has a low radar cross-section giving stealthy as well as furtive properties.

With regard to power requirements of the antenna 5, radio-frequency power may be coupled in a continuous wave fashion or pulsed at a selected frequency. Continuous wave coupling may be used for high frequency (HF), very high frequency (VHF), or ultra high frequency (UHF) transmission and reception. The plasma may be pulsed at intervals typically as short as a tenth of the plasma decay time allowing more efficient plasma production and lower power cost.

The gas from which the plasma is formed is typically, but not necessarily, a noble gas, the addition of other gases such as oxygen is also possible depending upon the plasma properties desired. Oxygen or a similar electron-scavenging gas can be added to damp signal ringing. Low radio-frequency power is required for operation of the invention, typically less than 200 Watts, the frequency range is typically 1 - 150 MHZ, with a gas pressure of a few milli-tor giving plasma densities of the order 10^{11} - 10^{12} cm^{-3}. The numbers mentioned hereinbefore should not be taken as limiting the scope of the invention but merely indicating typical operating parameters.

It will be understood that, whilst a very specific embodiment has been described,

numerous other variations and modification of the invention will become apparent to persons skilled in the art. All such variations and modifications should be considered to fall within the spirit and scope of the invention as broadly hereinbefore described.

In Figure 2 a plurality of tubes 2, formed in accordance with the above, are networked to form an antenna array 20. The individual tubes are operated form a central controller 21 and are selectively excited to permit control of an overall radiation pattern arising from the array, the mutual coupling between individual antennae produced, frequency stepping of individual antennae, power loading of individual antennae and the tuning of the array as a whole.

The manner of forming the plasma has been described as being by way of surface wave ionisation. Other means of ionisation used in connection with an electrode tube may achieve the same advantages of the invention. These means of excitation include but are not limited to travelling wave excitation, standing wave excitation, helicon wave excitation, microwave excitation, electrostatic excitation, or evanescent wave excitation, whereby the excitation means operates substantially in the radio-frequency range which includes, but is not limited to, high frequency, very high frequency, and ultra high frequency, said excitation means being coupled to the plasma as continuous wave or pulsed.

Claims:

1. A system for information transmission having a plasma antenna, including:
an electrodeless plasma tube; and
a power source effective to generate an electromagnetic field to cause ionisation of material within the tube so as to form the antenna for one or both of either sending or receiving signals, wherein the electromagnetic field is applied to a portion only of the tube.

2. A system as claimed in claim 1, wherein the system includes a terminal arranged about the tube at said portion for establishing the electromagnetic field upon application of power from the power source to induce surface wave ionisation within the tube.

3. A system as claimed in claim 2, wherein the power source is adapted to modulate the power applied to the tube such that the extent of the surface wave ionisation along the length of the tube, and thereby the antenna length, is variable to allow for tuning of the antenna to different operational frequencies.

4. A system as claimed in claim 2 or 3, wherein the surface wave ionisation is established to provide a net current along the length of the antenna, the current being modulated to carry a signal which is transmitted by the antenna.

5. A system as claimed in any one of claims 2 to 4, wherein the terminal comprises a band of conductive material positioned about one end of the tube.

6. A system as claimed in any one of claims 1 to 5, including a plurality of plasma tubes for forming an antenna array.

7. A method of communication, including providing an electrodeless plasma tube an establishing a plasma in the tube by surface wave ionisation to form a plasma antenna for

one or both of either receipt or transmission of signals.

8. A method as claims in claim 7, including supplying power to the tube to vary the extent of surface wave ionisation along the length of the tube so as to effect a change in effective length of the antenna and thereby allow the antenna to be tuned to different frequencies.

9. A method as claimed in claim 7 wherein a net current is established along the antenna for signal transmission.

10. A method as claimed in claim 9, wherein a single terminal is used to effect surface wave ionisation and signal transmission.

11. A method as claimed in any one of claims 7 to 10, wherein a plurality of plasma tubes are provided and selectively energised to form an antenna array.

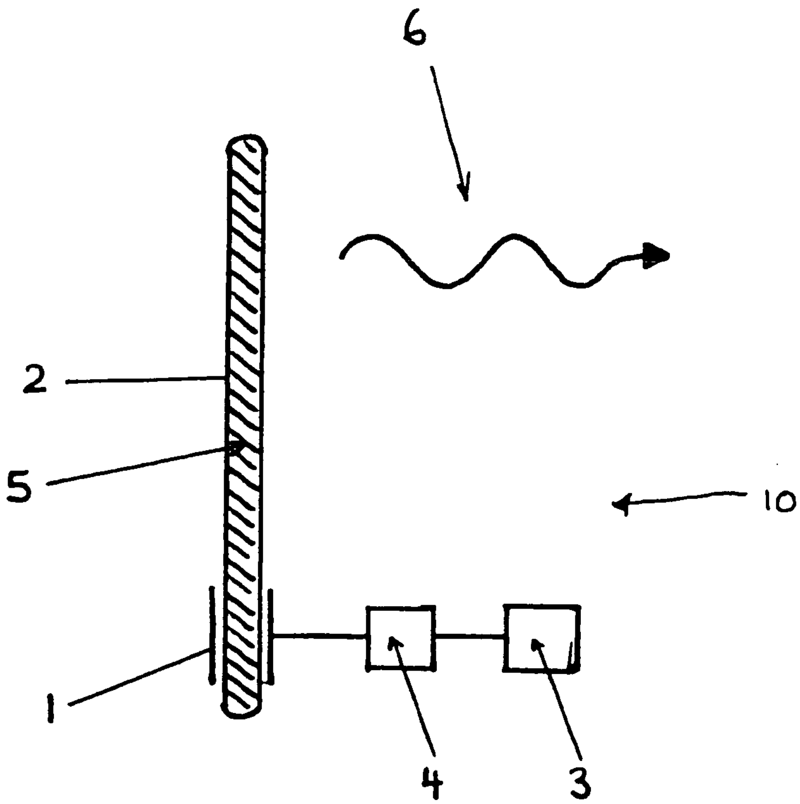

Figure 1.

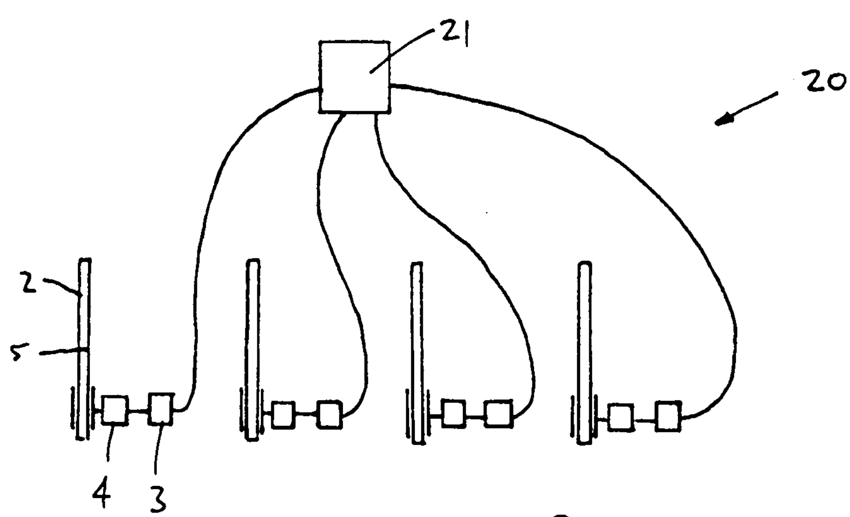

FIG 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU 99/00857

A. CLASSIFICATION OF SUBJECT MATTER

Int Cl^{6}: H01Q 1/26,13/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DERWENT: Plasma, Antenna
JAPIO: Plasma, Antenna

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,A	US 5963169A (Anderson et al), 5 October 1999 Whole document	1 - 11
P, A	US 5907221A (SATO et al), 25 May 1999 Whole document	1 - 11
P, A	US 5900699A (SAMUKAWA et al), 4 May 1999 Whole document	1 - 11

[X] Further documents are listed in the continuation of Box C

[X] See patent family annex

* Special categories of cited documents:

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Date of the actual completion of the international search	Date of mailing of the international search report
12 November 1999	19 NOV 1999

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU 99/00857

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5594456A (NORRIS et al), 14 January 1997 Whole document	1 - 11
A	US 5418431A (WILLIAMSON et al), 23 May 1995 Whole document	1 - 11

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU 99/00857

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member			
US	5900699	JP	10012396		
US	5594456	WO	9808269	AU	11145/97
US	5418431	EP	641151	JP	7109000
		US	5514936	US	5628831
		US	5696429		

END OF ANNEX